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EDUCATING THE PUBLIC ON HAWAII'S COASTAL ENVIRONMENT

WITH AN EMPHASIS ON MARINE ENVIRONMENTAL PROBLEMS

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ABSTRACT

OUR COASTAL MARINE ENVIRONMENT

Our coastal marine environment has been the subject of much attention lately. Much of this has to do with the increase in population on Oahu in recent years. With its growing number of people, Oahu's coastal areas have come under increased stress. Construction on and around the shoreline has displaced a great number of marine life including seabirds, turtles, and monk seals. Coral reefs and beaches have been bulldozed to accommodate the growing need for more hotels, condominiums and private residences. Oahu's coastline is eroding at a tremendous rate each year due not only to man induced pressures, but from wind and wave action as well. Breakwalls and other antierosion /.tsunami deterants have met with limited success. Erosion still takes place at an alarming rate in coastal areas.

One of the most serious problems facing our marine environment is that of dumping. Cars, boats, barges, as well as stoves, couches, and refrigerators can be found at various points throughout coastal Hawaii, but in particular on the leeward coast of Oahu. Effort has been made to clean these areas through state, city and county, and community involvement and it is hoped this problem can be solved in the very near future.

Oahu is the focus of Hawaii's tourism industry making it necessary to keep this island and all islands in the Hawaiian chain beautiful.

The problems our coastal marine environment faces are serious in nature, but with increased concern from citizens and visitors alike the beauty of our islands will not be lost to the disgrace of polluted oceans and beaches.

INTRODUCTION

In this paper I will discuss some of the problems facing our marine environments on and around Oahu. Oahu, as a geographic focus, was chosen for two reasons. The first being that this island, with its large human population also has a large number of environmental problems. The second reason was simply because I live on this island and that makes observing the problems here easier and less expensive than observing problems elsewhere.

The topics included in this paper range from problems facing coral reefs to those facing the Hawaiian sea turtle population. I would like to note that the amount of writing done for any particular subject in no way determines the importance of that subject over another. This merely reflects the amount of research given to a particular topic.

A photo essay in black and white prints accompanies this paper. The photographs were taken between September 1987 and March of 1988. I chose photography as a medium for this project because I feel photographs best capture a feeling, mood, or moment. I also believe photographs are an excellent communicator allowing the least amount of time and effort for a thought to be conveyed to its reader. At the present time black and white photography is the only process I am familiar with and that is the main reason why black and white photography was chosen over color for this project.

All photographs in this project were taken with a Canon A-1 35mm camera and a Canon 50mm standard lens. Some shots required a polarizing filter but this was to reduce glare and not for any special effect to the final prints. The film used was Kodak T Max 100 ISO.

I feel the final prints gave a good indication to some of the problems our marine environments face. By no means do I feel this project was a complete survey or representation of the marine problems here on Oahu. The amount of time given to any subject or geographic location was determined by my available time, as well as transportation, accessibility to a given area, and weather conditions.

In researching this paper I found many people, some considered experts in their fields, extremely helpful and eager to lend material that may have been of some benefit or to point me in the direction needed to find more information. Without their help this project would have proven to be a much more difficult task.

I would like to give thanks to Thomas Kelly for his help and advice with the photographic portion of this project. To Isabella Abbott, George Balazs, Sheila Conant, Bill Gilmartin, and James Maragos for their time and willingness to answer my questions, as well as lending material which often times proved beneficial to this project. To James Chow and Kent Takahashi for their assistance in gathering information on the O'hai plant, Sesbania tomentosa. To my wife Mari for her assistance in typing the many drafts which make up this final report and for her artistic skills in helping to cut mats and print signs for the viewing of the final prints at Hamilton Library. Special thanks goes to Sherwood Maynard who not only guided me through this project, but gave me the counseling which has helped me to complete my education here at the University of Hawaii. To everyone I am very appreciative.

DAMAGING FACTORS TO OAHU'S CORALS

When speaking of damaging factors to Oahu's coral and coral reefs we need to keep in mind that these are problems for other reefs throughout the tropics also. In my research of this subject I found the material to be quite interesting, but not specific in the sense of damaging factors to corals and coral reefs in certain geographical locations. I would like to begin with a brief introduction to the corals from a biological and morphological point of view.

Most corals are colonies of many small anenome-like animals called polyps. Each polyp secretes a small cuplike structure of limestone call corallite. The corallite provides support and protection for the soft-bodied polyp which is able to retract into the corallite, (an individual skeleton of a coral polyp), when not feeding (Fielding 1981). The polyp has a circlet of tentacles surrounding a central mouth which opens to the hollow body cavity. The tentacles are armed with stinging cells that enable the coral to capture tiny suspended animals call zooplankton. Polyps are continuously secreting calcium carbonate and form the exoskeleton which is visible to our eye. This exoskeleton gives the coral its shape. Zooxanthellae are single celled, yellow-brown algae which live within the bodies of the coral polyps. This is a symbiotic relationship, allowing both members to benefit from the association. The zooxanthellae can provide nutrition in the form of soluble carbohydrates which are leached out of the algae to the polyps allowing it to grow. The plant cells utilize nitrate and phospate which are waste products of the animal and this allows the plant to grow. It is believed that the plants may help to regulate the interior chemistry of the polyps allowing an easier way for calcium carbonate to be synthesized from the calcium and carbon dioxide in seawater.

If corals are of the reef building type, having the symbiotic relationship with algae, they are called hermatypic. Corals reproduce planula larvae which swim away to form new colonies. The asexual method is done in a budding fashion similar to many house plants and trees with a succession of building taking place on top of itself.

There are 3 different types of coral reefs around Oahu. The fringing reef which grows from the shoreline can be found in many areas around the island such as Ala Moana Beach, Waikiki, Pupukea, and Kahaluu to name a few. Barrier reefs are known to be separated from the shoreline by a lagoon such as the one in front of Kaneohe Bay. Patch reefs, also found in Kaneohe Bay, are less common on open shorelines but are often found in bays which are protected by a barrier reef or man-made structures such as break walls.

Biological Damaging Factors

The most damage caused to corals is by far from biological factors such as parrotfishes, Scarus sordidus, crown of thorn seastars, Acanthaster planci, sea urchins, Echinometra mathaei and bubble algae, Dictyosphaeria cavernosa to name a few (Maragos pers. comm.). Biological agents of destruction often weaken the substrate and make it more susceptible to physical and chemical erosion. The reverse situation occurs where damage caused by physical or chemical erosion facilitates bioerosion. Agents of destruction can be divided into grazing, etching and boring. Oftentimes there is an overlap between organisms, for example, urchins may be considered grazers and borers.

The principal grazers of coral reef substrates are the echinoids and a wide variety of fishes. They graze on live or dead coral substrates, coralline algae, and tuffed or filamentous algae growing on hard reef substrates in search of food. Surgeonfishes and parrotfishes scrape the coral

surface with their teeth producing new sediment. Both surgeonfish and parrotfish have an alimentary tract which is well adapted to carbonate ingestion. Parrotfish have massive parrot-like beaks of fused teeth for cropping the substratum, sets of pharyngeal bones which act as mills for grinding sediment and algae. These fishes also have well developed stomachs which in grazing species form a thick walled gizzard (Jones 1968).

Echinoids are major eroders of coral reefs in areas around Oahu where large populations of urchins occur. Echinometra mathaei and Echinometra oblonga, two common Hawaiian species can erode up to 30 kg. of calcium carbonate per square meter, per year in areas with population densities of over 80 urchins per square meter (Russo 1979). Russo also mentions that in these areas bioerosion can exceed calcium carbonate production. Echinoids both graze the coral and bore the coral surface to form a shallow depression for shelter. They use their Aristotle's lantern, a complex of plates surrounding the mouth as well as their spines to bore into the reef and rocks. It is believed that the Echinoids merely obtain nutrients from the algae attached to the coral substrate or from the living coral tissue.

Etching organisms include the algae, fungi, and bacteria. When conditions within the coral skeleton are optimal for vigorous growth such as light, temperature and nutrient concentrations, co-occuring phytoplankton blooms may expand rapidly. These algae are usually of the endolithic type (rock penetrating) and are often from the Cyanophyta Family (blue-green algae) (Highsmith 1981). Little is known about the etching processes of fungi or bacteria, but it is believed that fungi are one of the first endolithic organisms to attack skeletal debris.

Boring sponges have probaly received the most attention of all the groups of boring animals. Boring sponges form large chambers, with smaller galleries

branching off the main chambers. Depth of penetration varies, but usually does not exceed 20 mm (Wilkinson 1983). The etching areas consist of etching bodies and numerous associated cell bodies.

Most marine annelid worms are polychaetes. Several polychaete families have boring species. It is believed the mechanisms of boring in polychaetes are chemical dissolution of the coral substrate (Blake and Evans 1973).

Many factors determine the rates of bioerosion upon a reef. These include size of animal, hardness of the substrate, depth of penetration of the algae on which these organisms are feeding, and finally the life cycles and habits of individual species. Boring communities are not stable over time. Individuals are replaced and probably many generations of borers occur within the time span of a boring community. The components of a boring community may also change with time.

Consequences of biological destruction

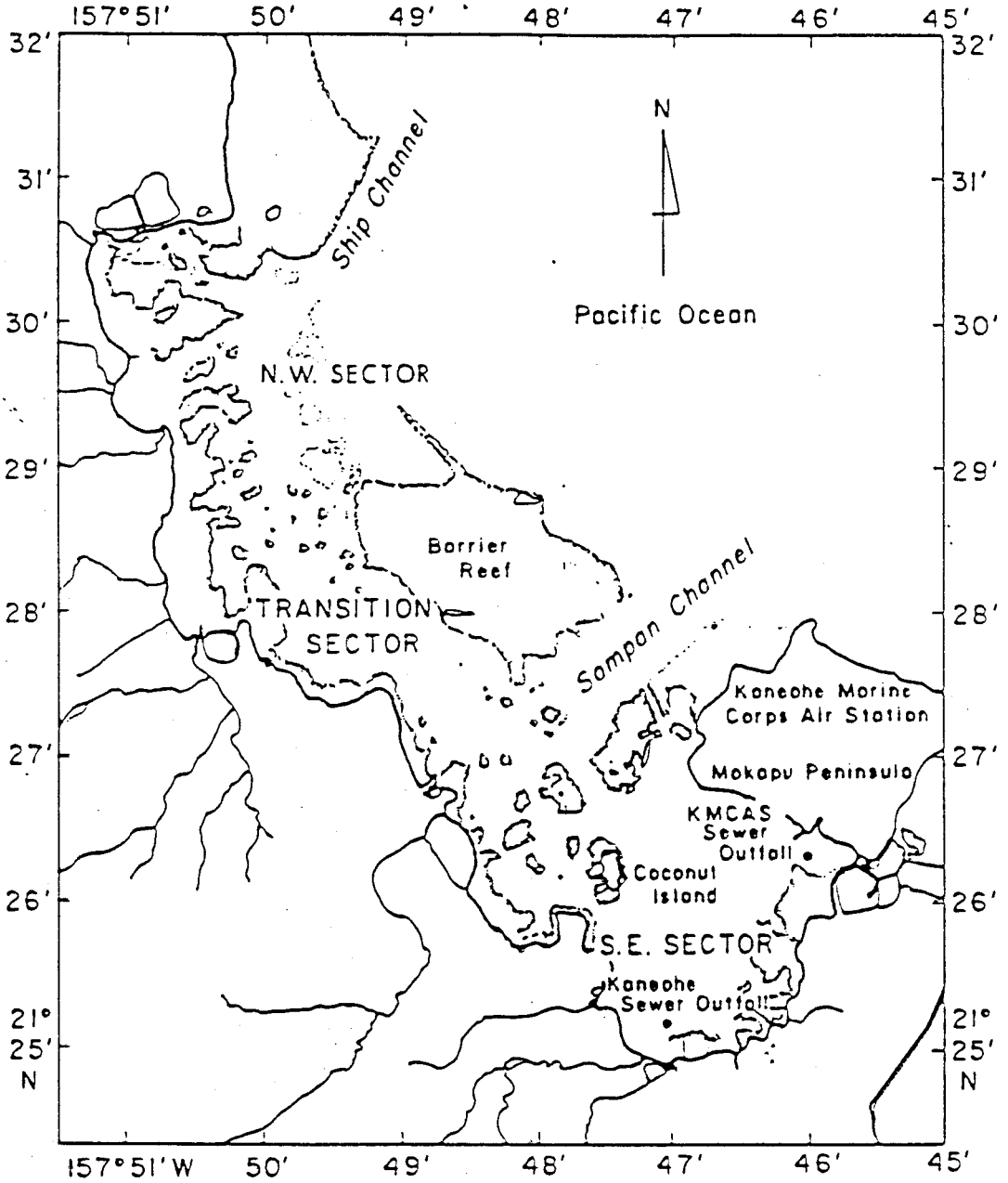
The impact of bioerosion on coral reefs is extremely complex. Bioerosion creates a large number of reef habitats, but it is the coral reef which suffers. However, Brock (1979) has shown that coral and coralline algal recruitment is more successful in areas subjected to heavy grazing pressures by parrotfish than in areas of low grazing. This activity may actually encourage and facilitate reef growth. Bioerosion then, although damaging to the coral, is still a very important agent determining the shape and form of coral reefs.

Kaneohe Bay
(Fig.1)

Kaneohe Bay on the northeast side of Oahu has an area of about 46 km^2 and a mean depth of about 6 m, although the average depth in the southeast sector of the bay is about 12-13 m. The salinity of the bay's waters normally

(Fig. 1)

KANEOHE BAY, OAHU, HI.



In Laws, 1981. Aquatic Pollution

falls in the range of 33-35 ppm , and water temperature varies seasonally between 20 and 27°C (Bathen 1968). A barrier reef that restricts circulation with the ocean extends along a good portion of the bay's mouth. The southeast portion of the bay is somewhat isolated physically from the rest of the bay by Coconut Island. As a result circulation in this part of the bay is not as good as in other parts, giving water a residence time of 24 days as opposed to 12 days in other parts of the bay. The Kaneohe Bay watershed is only slightly larger in area than the bay itself.

Concern over pollution in Kaneohe Bay has centered around the deterioration of the coral reef community. In an article written in 1915, MacKaye commented that 'probably no other spot in the Territory of Hawaii can show such a wonderful variety of corals as the waters of Kaneohe Bay...' By 1972, Maragos had reported a drastic change in the condition of the coral reefs. Based on a number of quantitative transects, he estimated that in the southeast sector 99.9% of the original coral reefs had died or been destroyed, and 26% had died in the northwest sector.

Urbanization of the Watershed

Most of the adverse effects on the coral reef system in Kaneohe Bay can be traced to problems associated with urbanization. Some corals were removed during the dredging of Mokapu Pennisula from 1939-1941 to facilitate construction of the Marine Corps Air Station. Dredging in itself destroyed coral by chopping them off at the base not allowing the coral to grow back. The most important change to the watershed came around 1940 when the population in that area increased at a rate of about 7.5% per year. The population went from about 5,000 people in 1940 to approximately 60,000 people today. Urbanization is associated with two processes that greatly increase runoff

problems.

First, the clearing of the land for construction, leaving much bare soil to erosion from rainwater. Second, roads, parking lots, and roof tops are impervious to water so rain falling on these surfaces has little chance to sink into the ground. Because of these runoff problems the erosion that takes place and the soil that was transported to the bay had an adverse affect on the corals. Salinity is reduced mostly on the top of the water having a damaging affect on corals close to the surface. (Corals can tolerate salinities in the approximate range of 27-40%) (Shepard 1973). In May of 1965, many corals were killed to a depth of 1.5 m after heavy rains. (Fan 1973) estimated that during heavy rains in the Kaneohe Watershed which occured on an average of 4-6 times per year, about 8,250 metric tons of sediment was dumped into the bay by the Kamaooli stream alone. Roy (1970) from his bathymetric studies, estimated the bay to be filled with sediments in about another 160 years.

Sewage Disposal

The first sewage treatment plant built in the Kaneohe Bay Watershed was constructed to serve the Kaneohe Marine Corps Air Station. The dumping was occuring in the southeastern sector of the bay at about 4.1×10^6 liters of sewage per day as of 1972. In 1963, another sewage treatment plant was built for people residing in the town of Kaneohe, discharching about 11.5×10^6 liters of sewage per day. In 1970, a third sewage treatment plant was built to serve a housing development in the Kahaluu area. This site began dumping treated sewage into the Ahuimanu stream in the northwest sector of the bay. The remainder of the watershed is still served by cesspools (Laws 1981).

The sewage discharge affected Kaneohe Bay in three ways. The first effect resulted in the loss of water clarity due to increased populations of phyto-plankton, particularly in the southeast sector (Laws 1981).

Because the algal communities were enhanced by nutrients from the sewage, these organisms (sponges, etc.) were allowed to flourish. This brings about the third effect of sewage on coral reefs. The stimulation in growth of Dictyosphaeria cavernosa, commonly known as bubble algae. This alga receiving the nutrient supplement established itself within coral heads at the base of a frond, and then grow outward eventually enveloping the coral head and killing the coral (Laws 1981). Maragos (1972), estimated that due to the low level of bubble algae grazers in the middle part of the bay, bubble algae killed many corals. Maragos estimated 24% of all corals in this section of the bay had been killed by this method. Therefore, sewage elevated the nutrient concentrations in the waters of Kaneohe Bay.

Sewage Diversion

Between December of 1977 and June of 1978 both the Kaneohe municipal and the KMCAS sewer outfalls had been diverted out of the bay because the circulation outside the bay was more adequate to handle the large amounts of sewage. Today, 10 years later, the bay is making a strong comeback. Dictyosphaeria cavernosa does not do well in conditions that are not eutrophic so it is unlikely that the algal strangulation will be a problem such as it was in previous years. Land runoff remains to be a problem in the bay and it is believed that for the state to design and implement an effective plan to control land runoff much money and a change in attitudes by local governments will be needed (Laws 1981).

Numerous other effects damage coral reefs both in a biological and physical manner. Some other biological destructive forces to Oahu's coral reefs include the crown of thorns seastar, Acanthaster planci which eats the

tissue surrounding coral polyps, the peanut worm of the genus sipunculans, which is not only a borer but a grazer as well, grazing on the zooxanthellae within the polyp and the spotted blenny, Exallias brevis, which rasps corals much the same way as parrotfishes.

Physical damage

Physical damage to Oahu's corals include storm and wave damage, breaking off whole heads of coral and often killing the coral beyond repair. Due to steep sloping very close to shore, storm swells can quickly change from deep water to shallow water waves, and wave energy can be transferred from horizontal to vertical at an extremely rapid pace (Dollar 1982). Steep plunging breakers are a result. Maragos (pers. comm.), estimates the recovery time for severely damaged corals to be around 50 years and 10-15 years for those corals not so badly damaged. Exposure to the sun by means of extremely low tides can kill off coral that have an endosymbiotic relationship with zooanthellae. This happens because the algae dry out and cannot continue photosynthesis.

It is within our power and interest to protect this unique marine ecosystem for many reasons. The reef community supplies food for daily consumption by humans. Research has not yet gone far enough to find out the potential of reef organisms for biomedical models and pharmaceutical value. Coral reefs provide recreation and educational value as well as a scientific source for research and information. A great benefit derived from coral reefs is the protection they provide from storms and high waves. Without the coral reefs our shorelines would suffer severe erosion. Hawaii, Oahu in particular, must take precautions to save these tiny organisms which far outweigh their size in the benefit they give to all who live in the tropics.

We will move next to marine algae. The algae are often very important

in the lifecycle of corals but they also carry on simple and complex life-cycles of their own. These marine plants are a resource within themselves and are something we should consider when making decisions which will effect our marine environments.

MARINE ALGAE

Algae can range in size from one cell to giant kelp. Marine algae fall into two categories based on size: macroalgae-the plants large enough to be seen with the naked eye and microalgae-tiny plants with the two most common forms being, diatoms and dinoflagellates. These plants live in a wide variety of weather and sea conditions. Most algae are found in lakes, streams and oceans, but many have been found on trees, in the air and even on snow-fields (Bold 1978). The main taxonomic classifications given to algae based on pigment of which all have chlorophyll a, include: Cholorophyta (greens), Cyanophyta (bluegreens), Rhodophyta (reds), and the Phaeophyta (browns).

Photosynthesis

Most marine algae are autotrophic so it is understandable that they can be found in the euphotic zone where 1% of the photosynthetically available light reaches. Because of their photosynthetic capabilities, algae play an important role as primary producers of organic matter for aquatic food chains, (this will be discussed later). Marine algae are governed by their photosynthetic capabilities for growth, as well as food production making them a self sufficient unit. Temperate zones, (those areas between the tropic of Cancer and the Arctic Circle or between the tropic of Capricorn and the Antarctic Circle), are limited in algal growth

at depths of 15-40 meters (Norton and Milburn 1972). Doty (1978), mentions algal growth to depths of 100 meters in Hawaii and to depths of 200 meters in polar regions. Dr. James Norris working for the Smithsonian Tropical Research Institute found Rhodolists, coral algae, at 928 feet below sea level (Norris pers. comm.).

Sedimentation

Sediments and plankton in the water column can act as barriers impeding the amount of radiation algae may otherwise receive. In areas where wave action stirs up the bottom, there is usually reduced algal growth, although on the fringes of the wave lap the growth can more than make up for this deficiency. Where rivers flow to the sea there is often a great deal of silting taking place. Depending on the ocean's ability to disperse these sediments and organic matter, there can be a large area devoid of any aquatic vegetation. Much the same holds true for coral reefs. Silt can act as a choke not allowing a foundation for a reef to be laid down.

Primary Production & Chemical Damage

Algae are believed to be the basis for most aquatic food chains. The second stage in the food chain are herbivorous fishes which feed on algae. Those fish can in turn be eaten by carnivorous fishes and on the chain goes usually ending at larger carnivorous fish or man. If there is a disruption at the beginning of the chain the repercussions will be felt through to the end. This should concern us considering how much we pollute our ocean environments with many harmful chemicals. If a chemical that was resistant to biological breakdown were to enter the food chain, it could be magnified through that chain due to the fact the chemical is stored in the fatty tissue of organisms rather than being excreted with other wastes (Laws 1981).

Once that organism is eaten by another the same process will occur, eventually concentrating the initial level and most likely the toxicity of the chemical or its residue.

Biological magnification has led to serious problems resulting in much human illness and death (Smith and Smith 1975). A study was done to determine the effects of DDT exposure on phqtosynthesis. The results showed the more DDT available to a cell, the lower the phosynthetic rate (Wurster et al 1986).

The excess in nutrients to algae can also set up harmful situations. If algae were to be enriched by nutrients leached from soil after a heavy rain or from sewage dumping, there would be an increase in biomass. Algal biomass will attract herbivores and can set up a potential problem for oxygen demand if the area containing the biomass is small and without good flushing of ocean water.

The algae will eventually be grazed down and their growth rates kept in check by those fish feeding upon it.

Humans have posed a large threat to algal growth because of the demand put on edible algae here in Hawaii as well as other places where algae is consumed by humans.

Algae is important in many different ways. These marine plants, much the same as corals, have potential as pharmaceuticals as well as an alternative nutrient source for humans. It is in our best interest to protect these plants so that all involved may enjoy the benefits they offer.

Moving closer to shore, our next topic will be wetland management. It is necessary to consider this area as a very important ecosystem when studying problems which face our marine environments. Many birds, both native and migratory, find refuge in Hawaii's wetlands. It is

crucial to their existence that they be protected from the potential dangers humans may inflict on them.

WETLAND MANAGEMENT

Hawaiian wetlands provide critical habitats for four endangered waterbirds, the Hawaiian duck or Koloa, Anas wyvilliana, the Hawaiian Coot, Fulica alai, the Moorhen, Gallinula chloropus, and Black-necked Stilt, Himantopus mexicanus.

Most of the large individual marshes or marsh complexes today are preserved due to interest of state and federal wildlife conservation agencies or private groups interested in wetland management (Weller 1982). At the state level the Department of Land and Natural Resources, (DLNR), is empowered to put into action rules for the purpose of protecting, conserving, propagating, and harvesting introduced and transplanted wildlife, game, and aquatic life (King and Schrock 1982). Under the DLNR there are three divisions which help to manage wetlands. These are the Division of Forestry and Wildlife, Division of Aquatic Resources, and the Department of Conservation and Resource Enforcement. Agencies at the federal level, under the Department of the Interior, which help to manage wetlands include the Fish and Wildlife Service, and the Department of Environmental Services (Ford 1987 pers. comm.).

Description

Wetlands are generally regarded as being low lying areas with much soil moisture. The vegetation in these areas tends to be tall grasses and low lying shrubs. Whereas emergent vegetation may be vital for nest sites for birds or food for other animals, submergent plants are substrates for the invertebrates that serve as a food source for ducks (Krull 1970). It was

Beecher (1942) who claimed that the number of bird nests were positively correlated with the number of plant communities in marshes. It is believed that dramatic changes in vegetation are caused by plant-water relationships (Weller 1982). Weller goes on to say that the size of a wetland is vital to the maintenance of marsh fauna especially when the marsh is relicit. It is understandable then, just how important plant roles are in the wetland areas.

Another large factor that plays a role in existence of wetlands is that of water. Salinity levels in marshes and estuaries not only affect what types of vegetation grow there, but as mentioned above, also affect the type of aquatic life available as food to wetland birds and animals. Natural or artificial dewatering ("drawdown"), can have a tremendous affect on vegetation which in turn can cause many species of waterbirds to migrate (Johnsgard 1968). However, the drawdown effect usually produces a subsequent "germination" phase allowing vegetation to come back, and with it may return the water birds. Weller (1982) mentions three general principles for marsh managements, they are as follows: 1-System, rather than species management, 2-Manipulation in producing early plant successional stages resulting in longer lasting benefits, and creating diverse habitat niches, 3-Maintaining heterogenaity in wetland marsh management. But Weller concedes there is no substitute for the manager getting into the marsh and working with the environment.

Obtaining Lands

Gaining control of wetlands is the best way to preserve these areas. Control by means of purchasing, leasing, or effecting a change in jurisdiction is more favorable to natural resource maintenance (Speth 1979). In the case of California, most of the funds are directed towards acquisition of lands and not so much for operational maintenance (Speth 1979). In most cases, wetland areas left undisturbed can manage themselves. For those wetland areas which are in close proximity to

urban or residential areas there needs to be some kind of management plan implemented. Depending on who owns the land, various agencies, (such as those mentioned above), or private groups such as the Sierra Club or Nature Concervancy, take on the responsibility for these wetlands. Most lands acquired for preservation or conservation have been designated ecological reserves (Speth 1979).

A primary reason for preserving those wetlands is to protect the habitat along with the fish and wildlife within these areas for public observation and scientific study (Todd 1979). The knowledge gained from studying these areas can help us better understand the intricate workings of the many ecosystems involved. This knowledge can also prove important in acquiring new lands for protection, as well as listing certain species as endangered or threatened.

Hawaii's Waterfowl and Waterbird Management

The Hawaii Wildlife Plan, (DFW 1984), contains plans for those birds which reside in the wetlands. The birds are listed as migratory waterfowl, resident waterfowl, and waterbirds. The Plan for migratory waterfowl include economic factors such as Plan D3.a., which states, "No programs or expenditures specifically designed for migratory waterfowl other than vigorous information, education, and law enforcement should be considered as long as public hunting is prohibited." Other plans for migratory

waterfowl include, 1 - prohibit hunting of migratory waterfowl until populations are high enough to warrant this and, 2 - providing habitats for these birds while designing and developing sanctuaries for endangered species.

If Hawai'i's wetlands are not preserved, its birds may perish. Humans, while creating some wetland areas,have also destroyed wetlands through development. By altering these habitats we have upset the natural balance needed for wetland organisms to survive and prosper. By educating the public regarding their moral responsibilities of sharing this world with other animals, we can save not only the birds and habitat within wetlands but the beauty as well.

When speaking of potential hazards to an environment, we must not only look at the environment as a whole or even the many ecosystems within that environment, we must also look at the individual organisms. Our next topic then will be the endangered plant, Sesbania tomentosa, 'Ohai.

'OHAI

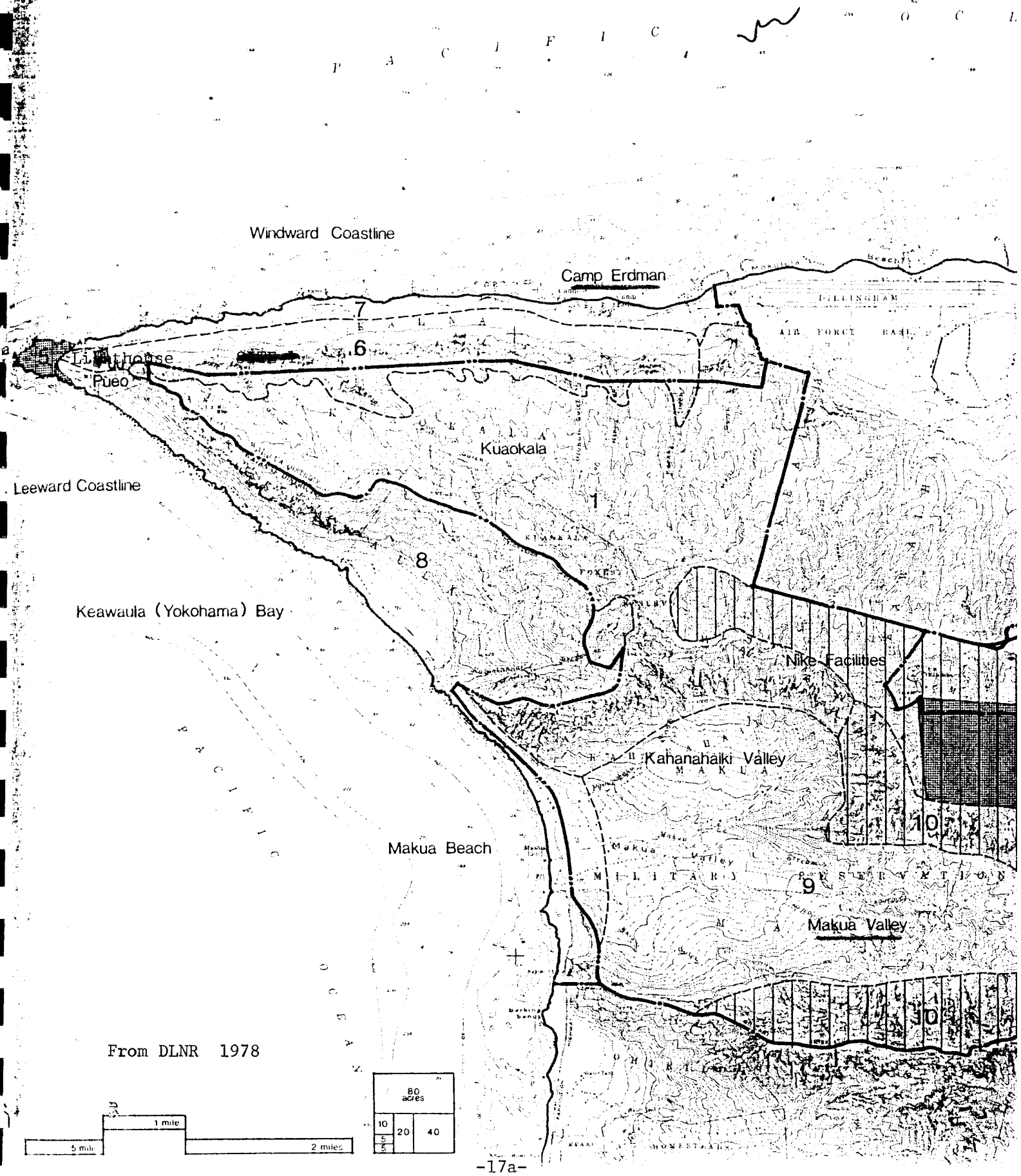
Sesbania tomentosa

Sesbania tomentosa, also known as 'Ohai is an endemic species of plant that is presently known to consist of two populations on Oahu. The population of S. tomentosa is limited in numbers and restricted to a particular ecosystem that is being threatened due to human manipulation of the environment. Long term management recommendations are set forth in the latter part of this section that could help to preserve not only S. tomentosa, but the surrounding area as well.

Ka'ena Point-Oahu

Ka'ena Point is located on the extreme west end of Oahu, (Fig. 2). As an isolated peninsula the point has both leeward and windward coastlines. The windward coast is subjected to direct exposure of predominantly north-easterly

Fig. 2
Sesbania tomentosa site location



MAKUA - KAENA STATE PARK

CONCEPTUAL PLAN

FLORA / FAUNA AREAS

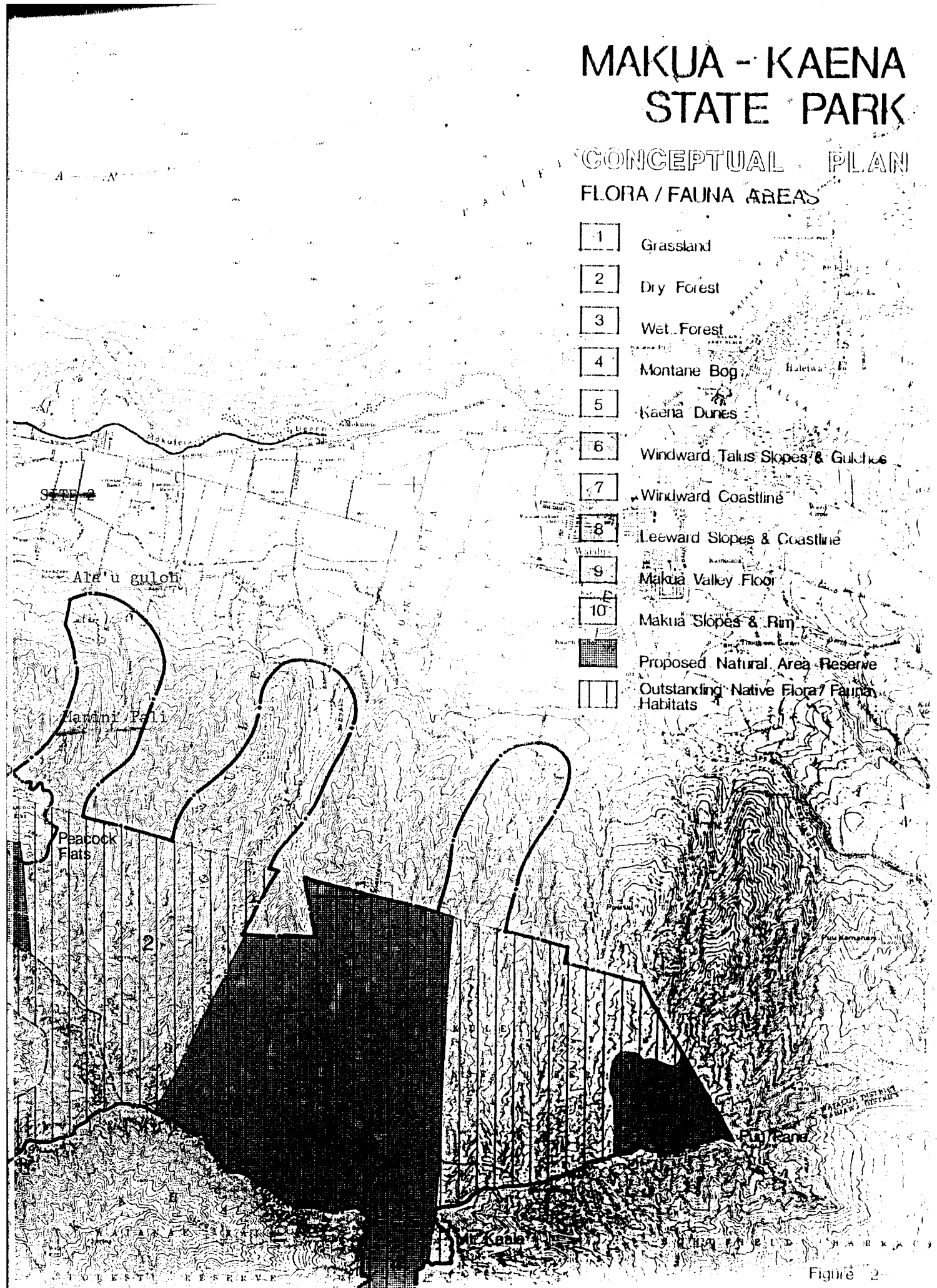


Figure 2

tradewinds where near ground wind speed averages 12.5 mph (Department of Land and Natural Resources, DLNR 1977). This coast must also bear the brunt of large easterly swells associated with winter surf on the north shores. The leeward side of the point is, for the most part, protected from the effects of the tradewinds and surf, although it is subjected to the north-west swells that occur periodically. The effects of ocean swells on the south shore of the point are reduced because of the rapid increase in ocean depth near shore and extending offshore, thus wave energy is not fully exerted (DLNR 1978).

The Ka'ena Point area holds great archaeological and historical significance, as it once was inhabited by ancient Hawaiians. There are archaeological house sites, hei'aus, as well as fishing shrines, koa's, present in the vicinity of Ka'ena Point proper along with other associated areas (DLNR 1978). In more recent times the area has been used for fishing, diving, camping, and off-road recreational vehicle use.

The DLNR accepted a plan for a state park in the Makua-Ka'ena Point area on October 14, 1977. The park was to encompass the 2,830 acres from Makua Valley, (leeward), to Camp Erdman, (windward). Within this area was a natural area reserve. This was identified as Ka'ena Point proper.

An environmental impact statement was prepared by the Environmental Impact Statement Corporation. According to this report the purpose of the park was to preserve the designated area's natural characteristics. The park area was also considered to be the only area left on Oahu that allowed the use of coastal, ocean, and mountain regions for recreational purposes (DLNR 1978).

Plant Description

This rare beach plant is a woody shrub that grows prostrate over the ground because of the stunting effect of dryness, heat, and wind. Its branches are silky and "wool" covered. The compound gray-green leaves have a whitish

tint which helps reflect some light, protecting the plant from harsh solar rays. The leaves range in size from one half inch to one inch in length. The inch and one half long flowers are orange or reddish in color (Merlin 1986).

The next two tables will describe the location and the observed status of the remaining S. tomentosa in existence on Oahu.

Table I

Species name: Sesbania tomentosa
Island: Oahu, Ka'ena Point
Last Observation by: Kent Takahashi
James Chow
Anthony Salvaggio
Last Observation Date: 11-22-87

Plant Location Directions: Ka'ena Point-approximately 220 meters from the lighthouse on Mokuleia side inshore approximately 100 meters from the water's edge. Elevation is approximately 40 meters.

General Description: Population is located behind and inland of sand dunes. Basaltic and coral sand environment with widespread Scaevola taccada (Naupaka). S. tomentosa is concentrated within a 10 meter square area.

Species Population Data: 36 individual plants noted. 29 healthy, 4 feeble, and 3 dead. No plants were in bloom.

Most plants were observed growing prostrate in the lee of naupaka shrubs. Those plants growing in lee of naupaka had a more upright form.

Table II

Species Name: Sesbania tomentosa
Island: Oahu, Ka'ena Point
Last Observation Date: 11-22-87

Plant Location Directions: (North of Ala'u gulch and Manini Pali) Approximately 100 meters east of dry river bed between the tenth and eleven telephone pole north of lighthouse. Approximately 40-60 meters inshore from the water's edge. Elevation, approximately 4 meters.

General Description: Plants can be found where vegetation line begins. Growth

occurs among the basalt and limestone fragments with brown soil intermixed. Other plants include Scaevola taccada(Naupaka),Sida fallax (Ilima) and various grasses.

Species Population·Data: 18 individual plants sited. 14 healthy, and 4 feeble. Plants are pale yellow-green in color. Growth is not as vigorous as population in table I. Many leaves have holes presumably from insects feeding on plants.

Observations

During the two trips that were taken to the site, the first being on 11-19-87, numerous recreational vehicles were observed. Many vehicles came close to and at one time ran over a clump of plants. The road has been carved into the land by these recreational vehicles leaving one of the two stands of S. tomentosa as an island with its sandy coast being eroded away. Plants on the fringe of this plateau are being run over by recreational vehicle tires as well as trodden under foot traffic in the area.

Recommendations for Management

The natural coastline ecosystem at Ka'ena Point is now part of the Natural Area Reserve System, but no management programs have been implemented to preserve the area. Since state funds have been appropriated to begin research on and actively manage the state's reserves this year, the proposed site at Ka'ena Point may get underway and active longterm management plans can be intitiated. It will be important to initiate a program that would either limit all access to the point or at least block off land containing populations of S. tomentosa with large boulders or some other means of protection. Because the plants of S. tomentosa are in two separate areas it would be necessary to secure 300 acres of the 2,830 acre park. Short term management could be taken by erecting lava rock walls, (similar to those built by ancient Hawaiians), to protect S. tomentosa. Also signs could be posted to inform the

public on the need for preserving these areas. Further research is essential for better management of the coastal ecosystem. This was made apparent by Char, (1983) when she stated there had not been enough detailed morphological and comparative studies on S. tomentosa. It is important to look at this endangered, endemic plant and find ways of preserving not only it, but the area which surrounds this plant. so that extinction of Sesbania tomentosa does not occur.

We move now from an endangered plant to an endangered marine mammal, the Hawaiian monk seal.

HAWAIIAN MONK SEAL

The Hawaiian monk seal Monachus schauinslandi is an endemic species to the Hawaiian Islands. The monk seals' numbers are estimated between 500 - 1,500 animals.The range of the Hawaiian monk seal is throughout the Hawaiian Island chain although most of the population can be found on the small islands, atolls, and shoals of the Northwest Hawaiian Islands,(Fig. 3).

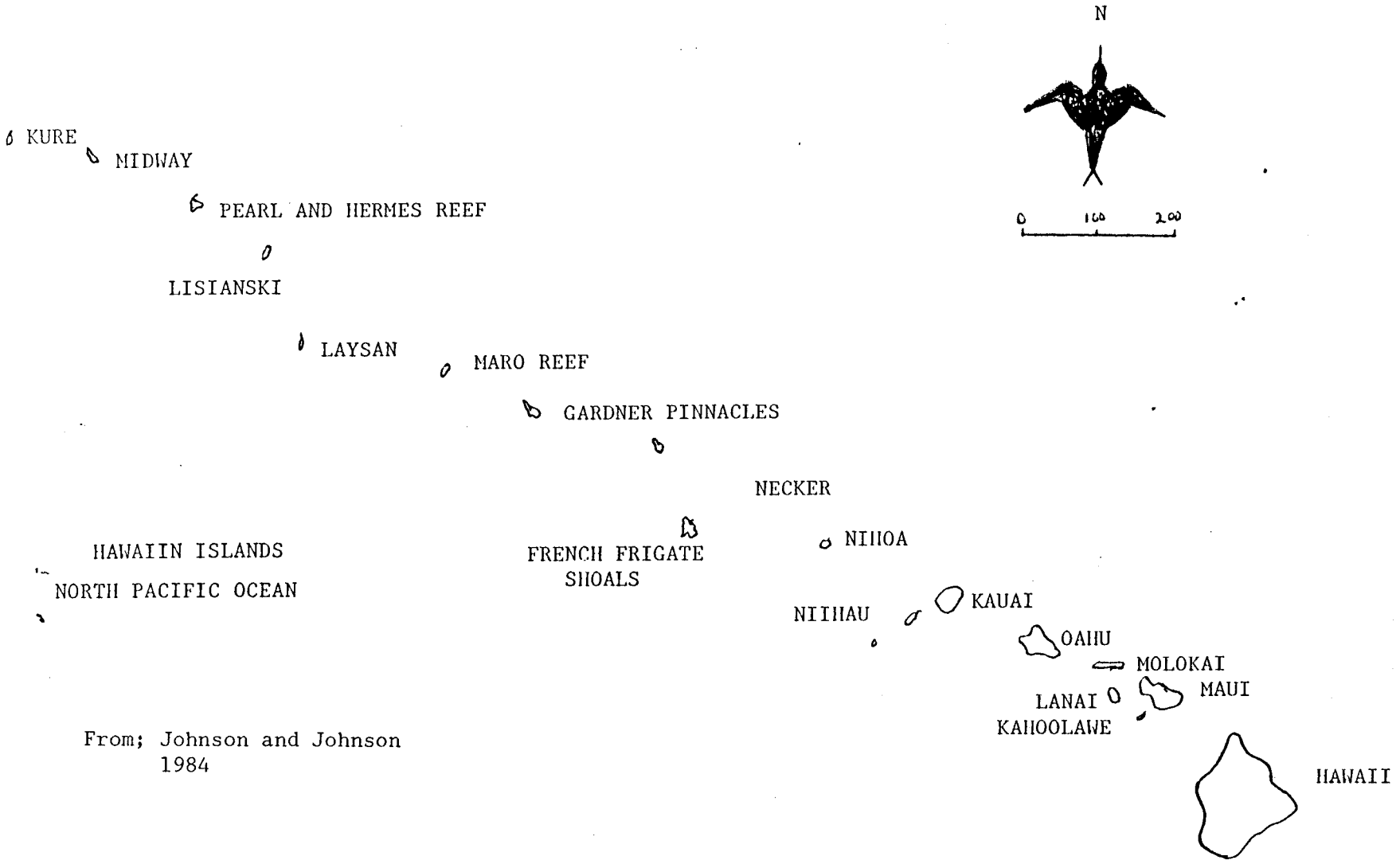
For years the Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, (NMFS) has conducted field studies of the Hawaiian monk seal. The purpose of these studies has been to learn more about these mammals so that we may better understand them and hopefully save them from extinction.

Protection

The Hawaiian monk seal was designated as depleted under the Marine Mammal Protection Act of July 22, 1976. On November 23rd of that same year the Hawaiian monk seal was designated as endangered under the Endangered Species Act (ESA) of 1973. Under the ESA the word endangered is defined as any species which may become extinct throughout all or part of its range within

(Fig. 3)

HAWAIIAN ISLANDS



From; Johnson and Johnson 1984

the near future. With the help of the NMFS and other national and state organizations, the Hawaiian monk seal is beginning to make a steady comeback.

It is believed that the Hawaiian monk seal population has suffered a serious decline of more than 50% since the late 1950's and is in need of strict protection (Gerrodette 1985). The reason for this decline is not yet known, but possibilites include human disturbances as well as being preyed upon by sharks (Gilmartin pers. comm.). More recently studies have shown that the problem of mobbing, (many males attempting to mate with a single female), has also contributed greatly to the decline in monk seal numbers (Gilmartin pers. comm.). This will be discussed later. The NMFS has conducted field studies to locate seals and estimate populations from beach counts. The problem with the beach count method of determining population is that not all seals are on the beach at any one time. This has led the NMFS to estimate the population to be two to three times larger than that number found on the beach. April to July beach counts averaged 473 seals in 1983 and 501 in 1985. Identifying one monk seal from another can be done by tagging the animal or from distinct markings such as scars or bleach marks applied to pups for this identification reason (Gilmartin pers. comm.).

Mating

From data obtained on Laysan Island between 1977 until 1980 it appears sexual maturity, as measured by first birth, may not occur until after five years of age for females (Johnson and Johnson 1984). The mating behavior of the Hawaiian monk seal is not as well documented as the problem of adult male "mobbing." Mobbing has been the topic of great concern for those interested and involved in the Hawaiian monk seal's future. In February of 1987, a workshop to address the Hawaiian monk seal adult male problem was held in Honolulu, Hawaii. Because mobbing is believed to be one reason for the decline of the monk

seal population the plan of this workshop was to come up with a solution to the problem. Behavior modification and removal of male monk seals were found to have the greatest effect on this problem. Removing some of the males was viewed as a way to bring the population more toward unity. The aggressive male behavior is believed to be linked to testicular activity. Increased pituitary function, driving an increase in testicular androgen production is generally associated with increased male aggressiveness and related male advances toward females or other non-androgenized individuals. It is hoped that a decrease of this behavior can be developed by administering a reversible chemical treatment to the males (Gilmartin and Alcorn 1987).

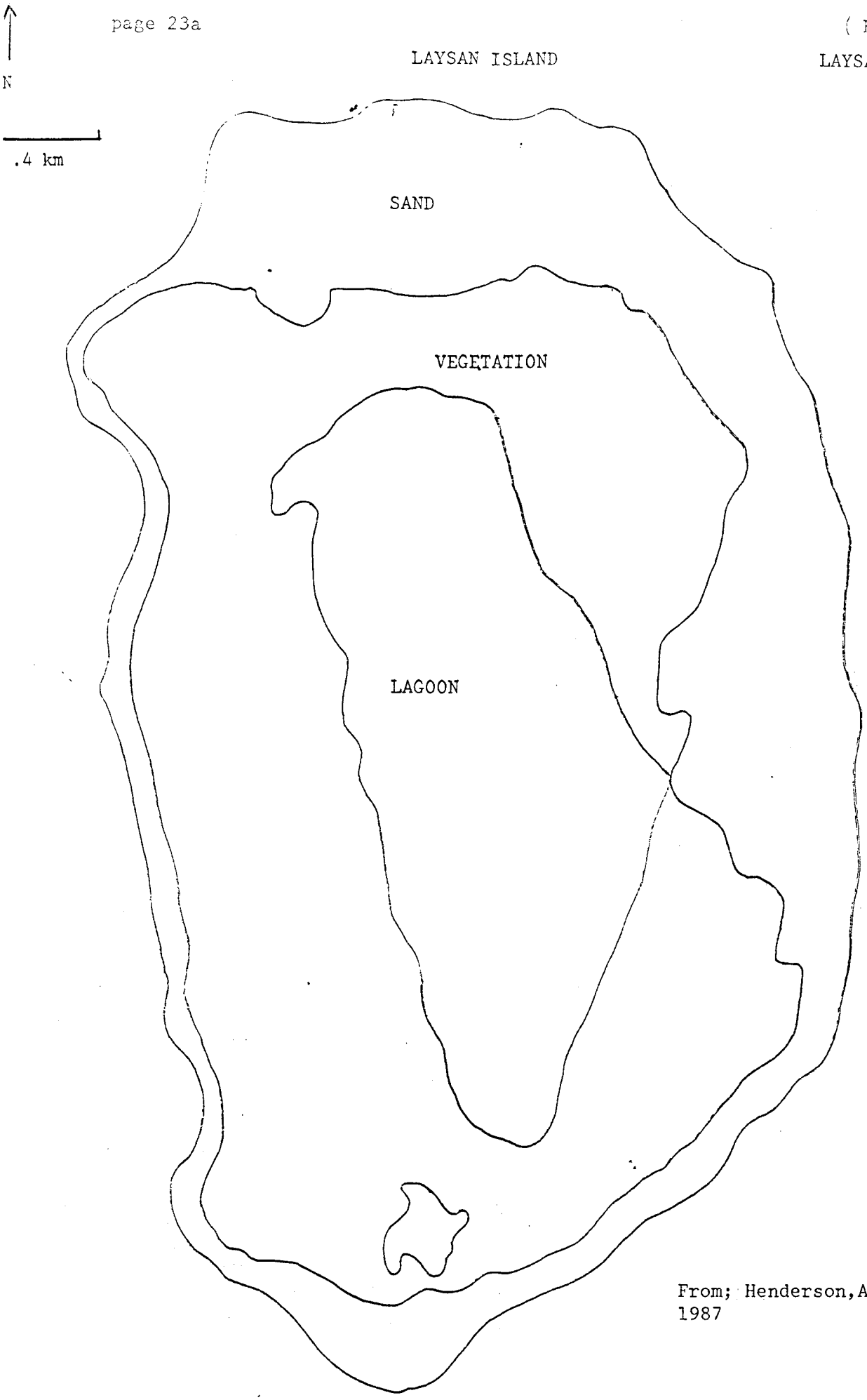
Hazards Facing Monk Seals

Hazards to monk seals include both natural and man-made types. The greatest natural threat to the seals are tiger sharks as well as grey reef sharks (Alcorn and Kam 1986). Until recently it was believed that sharks attacked only young or injured monk seals. In May of 1982 Alcorn and Kam while involved in a field study off Laysan Island observed an attack on what appeared to be a healthy female monk seal. They noted, however, that puncture wounds had been observed on the back of the seal for approximately 3 days, but this was believed to have been a mating injury (Alcorn and Kam 1986). * (Fig. 4)

Alcorn and Kam went on to observe the monk seal being pulled under and consumed by two large sharks as well as numerous smaller sharks and frigate birds looking for leftover scraps. The largest man-made hazard to monk seals, aside from hunting,in the past, would have to be that of lost or abandoned debris (Gilmartin pers. comm.). Much of the debris reached the islands and atolls by southern movement of water from the eastward flowing north Pacific current to the westward flowing north equatorial current. The high seas squid gill net

(Fig. 4)

LAYSAN ISLAND



LAYSAN ISLAND

From; Henderson, Austin, Pillos 1987

fishery as well as the groundfish Trawl fishery in the north Pacific and Gulf of Alaska are responsible for much of the fishing gear found in the northwestern Hawaiian Islands (Henderson 1984).

Monk seals being curious animals tend to investigate this floating debris and can easily be entangled in that debris should they decide to play with it. Seals may also attempt to make a meal of the fish already caught by the nets and in their pursuit of a "free" meal become entangled. Other debris such as plastic bags and various floatsam items can become wrapped around body parts of the seal and cut off circulation and often lead to the loss of a flipper or even death from strangulation (Gilmartin pers. comm.).

Prevention

The NMFS has begun burning the debris once enough has built up on the surrounding coastlines. By having vessels keep stricter guidelines for the safe return of fishing nets much of this entanglement problem can be reduced. There needs to be a greater awareness on the part of all those on board merchant and recreational craft when it comes to dumping. Much of this debris is not biodegradable and presents many potential hazards not only to monk seals, but to other marine organisms as well. We as a race are responisble for much of the decline in monk seal numbers. We have destroyed critical habitat as well as scared away these animals merely by our presence. It is now up to us to do what we can with what resources we have to save this species from the same direction its relative, the Carribean monk seal, went. Extinction.

Our last major topic of this paper will be on another marine animal, the sea turtle. Here in Hawaii there has been great concern for the future of the Hawaiian green sea turtle and the Hawksbill. This is partly due to the loss of habitat and other disturbances by humans much the same way as has happened to the Hawaiian monk seal and countless other endemic and native Hawaiian

organisms throughout the Hawaiian island chain.

PROBLEMS FACING HAWAIIAN SEA TURTLES

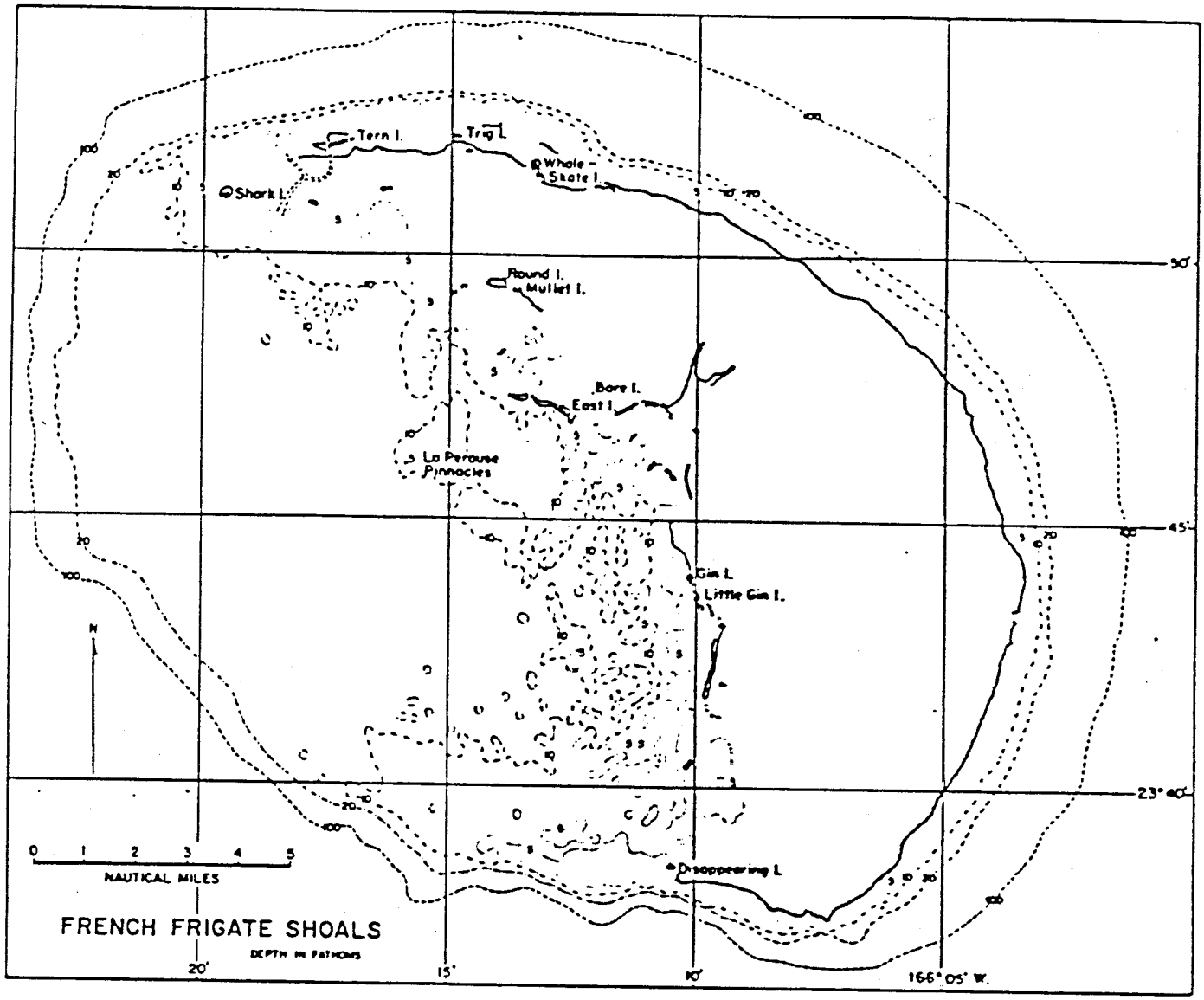
I will focus mainly on the Green sea turtle, Chelonia mydas and the Hawksbill, Entomochelys imbricata. Both species are listed under the Endangered Species Act of 1973 with the Green sea turtle listed as threatened and the Hawksbill as endangered (Endangered Species Act of 1973). As a result of these turtles being protected by both federal and state agencies, through tagging and enforced fishing and hunting laws, there has been more information made available on nesting and migration habits of the two species.

Eggs, Hatchlings, and Juveniles

The most critical time of life for the sea turtles not only in Hawaii, but the world over would have to be as eggs buried in the sand by their mother. On French Frigate Shoals (Fig. 5), where 90% of Hawaii's green turtle population nest, Ghost crabs, Ocypode ceratophtalmus and O. laevis have been known to burrow into turtle nests leaving them susceptable to other predators (Balazs 1980). These crabs also prey on hatchlings making their way to the ocean (Balazs 1980). Disturbances to nest sites have been observed by Hirth (1971), who witnessed rats, mongoose, and feral dogs eating turtle eggs. Migratory shore birds such as the ruddy turnstone, Arenarea interpres and golden plovers, Pluviales dominica have been observed eating eggs after the nest was disturbed by other predators (Balazs 1980). Other natural hazards to sea turtle eggs and hatchlings are storms with heavy rains, and erosion to the beaches nests are on. Once out of the egg, hatchlings may stay in the nest site beneath the beach surface until nightfall (Stancyk 1981). There is usually a quick dash to the surf once the hatchlings have broken out of the nest. At French Frigate Shoals, hatchlings

(Fig. 5)

FRENCH FRIGATE SHOALS



From; Henderson, Austin, Pillos 1987

emerge from their nests between the months of July to October (The Hawaiian Sea Turtle Recovery Team 1987). Artificial illumination has been attributed to disorienting the hatchlings and they head in a direction away from the ocean (Mager 1985). This problem of artificial illumination could lead to even more deaths by predation than the already high incidence rate of hatchling mortality. It has been estimated by Hirth (1971), that only 50% of the eggs hatch successfully and only 1-3% of the hatchlings reach sexual maturity. Hatchlings, having survived the two-month incubation period in the nest and the trek to the surf, have only completed a small portion of their life-long struggles.

The first two years of life for sea turtles is a period of time which, for the most part, is unknown to scientists. Young turtles spend the first two years of life in the pelagic zone (Balazs 1980). Pritchard (1967), has witnessed juvenile sea turtles floating on sargassum algal rafts where they may not only be safe from most predators, but are provided a food source as well.
Sea turtles with a carpace length of less than 35 cm are rarely seen near shore in Hawaii (Balazs 1985).

The Green Sea Turtle

Although 90% of Green turtles in Hawaii nest on French Frigate Shoals, many are found in the coastal waters off the eight major islands in the Hawaiian chain (Balazs 1980). Green turtles are considered long distance migratory species traversing vast distances of ocean from feeding spots to areas where they mate and nest. Females return to nesting beaches every 2 years to mate and nest while males usually return every year (Balazs 1980). These turtles are primarily herbivores that feed on sea grasses and green algae such as, Ulva and Codium (Balazs 1980). Balazs goes on to mention that these

turtles have been documented feeding on one marine angiosperm and 9 types of invertebrates, as well as 56 algae species of which 9 species account for the major part of their diet. The green turtles spend much of their time in shallow bays and estuaries where sea grass is likely to grow.

In the green turtle there is no marked size difference between the male and female sexes, but males are distinguished by their long thick tails. The name 'green' turtle stems from the color of their fat. The shell of the animal is olive-green, brownish or even bluish black (Pritchard 1967).

Sexual maturity in green turtles may take from 10-60 years (Balazs 1980; Zug and Balazs 1985). The breeding season, specifically at the French Frigate Shoals, lasts for about 4 months from May-August (The Hawaiian Sea Turtle Recovery Team, 1987). If they are to survive to replace themselves, these turtles must avoid not only predators from within the sea, such as tiger sharks, Galeocerdo cuvieri (Stancyk 1979), but from above the sea as well. Man has the dubious distinction of being the number one predator of all ~~to~~ sea turtles, not just the green turtle. Man has exploited, and continues to exploit green turtles for gourmet food, cosmetics, leather, flesh, calipee, oil, and skin (Stancyk 1979). This exploitation has been curbed due to the Endangered Species Act of 1973, still where there is no enforcement of the laws or for countries which have not agreed to all of the law, there is still money to be made on sea turtles. Archie Carr (1967), a well known scientist on sea turtle studies said, "There can be little doubt that people have been eating turtles pretty steadily for as long as they have had the wits to get them out of their shell."

Hawksbill

The Hawksbill gets its name from the shape of its snout. This is most likely an evolutionary adaptation (adaptive shift) for eating algae in hard to

get places and breaking off soft corals. These turtles are omnivores and eat algae, sea grasses, soft corals, mollusks, crustaceans, sponges, jellyfish, and sea urchins (Carr and Stancyk 1975; Groombridge 1973). The Hawksbill is less of a long distance migrant than other sea turtles (Pritchard 1979). Hawksbills tend to nest between July and November every 2-3 years in the eight main islands of Hawaii with some turtles preferring black sand beaches (Balazs 1980). These turtles tend to nest among the thick vegetation at the rear of a beach platform (Mortimer 1982). Nesting takes place spread out along many kilometers of undisturbed beach (Witzell 1983). This has probably helped their numbers because there isn't a large, concentrated accumulation of eggs for land predators to disturb. Females are particularly sensitive to beaches where artificial illumination is a factor. Females are also sensitive to shadows from people, animals, and trees and will rapidly return to the ocean without finishing the nesting process (Carr and Stancyk 1967).

Mager (1985) has noted it is difficult to census Hawksbill because their nests are hidden under thick vegetation.

Predation has been said to be high although documented cases are unknown (Witzell 1983). It is believed that predators to the Hawksbill in Hawaiian waters are those same predators to the green turtles, namely tiger sharks. Natural forces that affect Hawksbills, especially during the nesting process, include storms, temperature, rain, and wave surge (Witzell 1983). This can prevent nesting, destroy eggs and hatchlings and reduce nesting success.

Hawksbills are less threatened as a food source because of sporadic fatal poisoning that has resulted from man eating their meat not only in the past, but in present times as well. This poisoning effect has been attributed to the Hawksbill's diet of sponges (Hawaii Sea Turtle Recovery Team Report 1987). It is generally accepted that most nesting populations are declining due to

habitat destruction and over exploitation (Witzell 1983).

Recovery

The final draft of the Hawaiian Sea Turtle Recovery Team Report was released for corresponding consultants to the plan on October 1, 1987. The turtles included in this recovery plan are, in order of priority, the Hawaiian Hawksbill, the Hawaiian Green Turtle, the Leatherback, and the Olive Ridley. The last two turtles are found in Hawaiian waters, but there are no known nesting sites. The recovery plan is a result of work put together by a team made up of 7 people, 5 of whom are from Hawaii, 1 from Florida, and 1 from Utah. Together they have come up with a plan that will aid in bringing back the populations of the sea turtles mentioned above. The plan begins with a prioritized listing within species for important management and research actions. There is a biological overview of each species mentioned before going into the limiting factors facing these turtles. Factors identified are: human take, predation, disease, and habitat alteration within the marine and terrestrial environments. This 95 page recovery plan had been in the works for some time and now it serves sea turtles of Hawaii as a blueprint in which to help increase their numbers.

Sea turtles face danger every day of their lives. They run the risk of being eaten by sharks, caught in fishing nets or dying from diseases, such as fibropapillomas, a disease only known to green turtles (Balazs 1985). Turtle populations have been decimated from overexploitation by man. We have used their meat in soups, their shells as jewlery and their hides as clothing. We are now to the point where we realize protection is the only way to bring back their numbers. It is doubtful they will ever return to the population of years ago. Six of the world's seven species of sea turtles are endangered, with the seventh, the green sea turtle, being threatened. We have taken what nature has built

over millions of years and wasted it within approximately 4 centuries. It is no wonder sea turtles avoid man as much as possible. Hawaii it would seem has been a place of refuge for some species since the Endangered Species Act of 1973. There are still dangers. Habitat destruction may come from the development of homes, recreation, or industry on nesting beaches. Feeding grounds can be polluted by oil and gas spills. People ignorant of the law can shoot or net sea turtles and stand a good chance of getting away with it due to lack of enforcement. There are places in the world where trade of sea turtle products continues even today. Countries which have not yet ratified the CITIES (Convention on International Trade of Endangered Species of Wild Fauna and Flora) treaty or have reservations on certain species can escape punishment by law should they deal in endangered species trade. Even countries that have signed CITIES may not have the legislation to fulfill the requirements of the convention (Wells et al 1979).

It is easy to feel discouraged and frustrated when so many more people are still destroying them in other parts of the world. If we continue to protect turtles here in Hawaii the results can only be positive. Because sea turtles take a long time to add substantial numbers to their populations, it is necessary to keep protecting them for years into the future.

Cause for Concern

The one thing which caused me greatest concern while visiting the different coastal areas was the problem of litter. There was not one stop during any trip that was void of some form of debris; beer containers seemed to be the number one item in terms of quantity with sometimes hundreds of cans and bottles found in certain locations. In most cases the bottles were intact, not having their jagged edges sticking out of the sand for some unknowing person or animal to walk on, however, many bottles were caught in bushes and lodged between rocks leaving them prone to breakage by wave action. Other types of litter included combs, rubber sandals, coffee cups, hot dog wrappers, bubble gum, toy soldiers, strapping for beach chairs, shopping carts and countless other items that were not only unappealing to look at but harmful to marine life as well. It appeared that an effort had not only been made on the part of state and city/county workers to supply beach parks with trash receptacles, but to keep them empty so that over-flowing trash was not a problem.

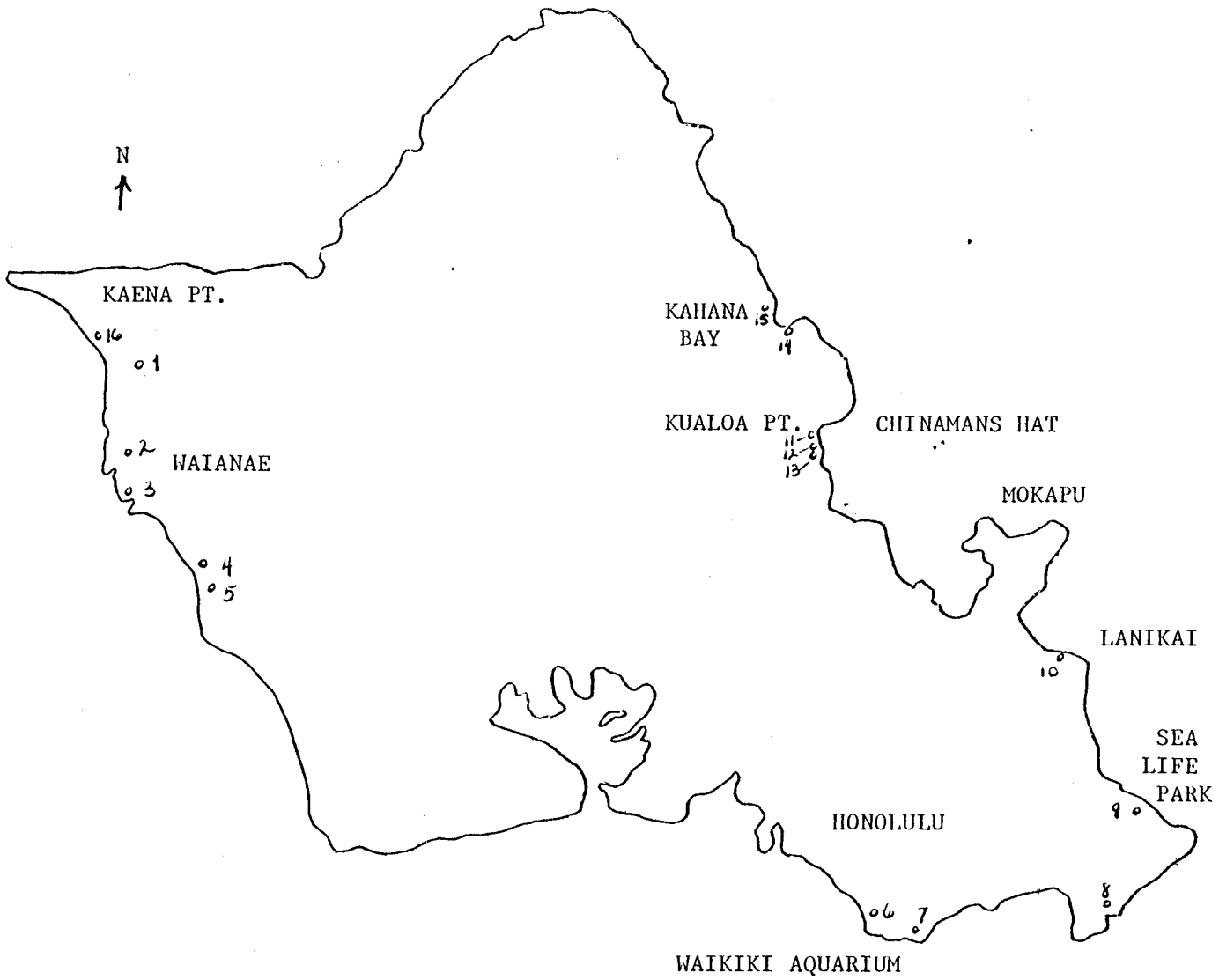
The beaches and their surrounding area are public domain intended for the use of all people both local and visiting. Hawaiian beaches are among the most beautiful beaches in the world when kept clean and free of litter. There will surely be a decline in the numbers of visitors to the islands if the litter problem is not confronted. With as many areas around the state plagued by the litter problem, one would think more should be done to solve these unsightly messes.

Solutions to the litter problem could be more legislation implementing a bottle bill making it worth someone's while to hold on to glass beverage containers. Hiring people to enforce litter laws and making offenders' names public could possibly discourage coastal littering. Educating the public is another way of

countering this problem. By cleaning up our beaches and coastal areas we can make these areas safer for both animals and humans alike.

(Fig. 6)

LOCATION OF PHOTOGRAPHS



1. Rusted Barrel
2. Abandoned Car
3. Couch and Pot
4. Stove
5. Dumped Trash
6. Get the Drift
7. Hawaiian monk seal
8. Storm Drain
9. Green sea turtle
10. Bent Sign
11. Exposed Pipe
12. Exposed Roots
13. Uprooted Tree
14. Dead Duck
15. Pipe Repair
16. Folding Bed

OUTLINE OF TALK AT
THE MARINE OPTION PROGRAM SYMPOSIUM

The talk given by myself at the MOP Symposium,held at Windward Community College was entitled, A Look at Some of Oahu's Marine Environmental Problems. I spoke for fifteen minutes on the photographs I had taken for my MOP skill project. Slides were used to represent the photographs which were matted and hung for display during the symposium. An outline of the talk and slide material in the order in which they appeared were as follows;

Introductuon about myself and how I became interested in our marine environment. How that interest carried over with my move to Hawaii.
Joining the Marine Option Program.
Areas I visited for the project.
Slide #1 Trash, Waianae coast

#2 Folding Bed, Waianae coast ..... Spoke on the problem of dumping in the Waianae and Leeward area on Oahu

#3 Abandoned Car, ... Spoke on the problems with abandoned vehicles and what is being done to solve the problem

#4 Couch and Pot,
#5 Rusted Barrel ..... Spoke more on the problem of dumping and what may be the reasons for it on the Leeward side of the island.

#6 Get the Drift and Bag it, Magic Island ..... What local organizations are doing about the litter problem.

Natural problems

#7 Exposed Pipe,
#8 Exposed Roots,
#9 Uprooted Tree, ... Spoke on some of the problems of erosion, construction of breakwalls to slow down erosion , wind and wave damage to a coastline.

Outline of MOP Symposium Talk Continued :

Problems facing our marine animals.

Endangered vs. threatened status

#10 Monk Seal , ... Hazards which they face , both natural (sharks) and man.

#11 Green Sea Turtle , Same topics of hazard,facing sea turtles

Problems with keeping drain pipes cleared and possible results when blocked such as the New Years Eve storm.

#12 Drain Pipe, Diamond Head

Final shot and summing up of problems

#13 Dead Duck, Kahana Bay, ... Possible causes of death,problem of illegal hunting. disposal of plastics

Ended with a five minute question and answer period.

What I Got Out of MOP

In the time since I first joined the Marine Option Program three years ago I have become more interested and more aware of what is happening in and around our worlds oceans. I have had the pleasure of meeting some very fine people while at MOP. There was always a frienly atmosphere whenever I attended a MOP function or even for a visit to the lounge. That in itself was sometning very special to me. I regret the fact that my time at MOP was not more productive. I look back on all those Seawords issues and wish I had been a part of more of the happenings at MOP. During my time with the Marine Option Program I have been able to find out more about myself. Things like,why I am such a great procrastinator and how being behind the eight ball is never any fun. I have found these things about myself because I was challenged , words I will never forget from Sherwood while I was being counselled during this,my last year at U.H.; " Challenge yourself" Sherwood said, and I have found myself taking that test more and more often. Thankyou Sherwood and Thankyou MOP.

APPENDIX

APPENDIX

Photographs	Location	Date
1. Trash	Waianae coast	December 1987
2. Folding Bed	" "	October 87
3. Abandoned Car	" "	September 87
4. Couch and Pot	" "	October 87
5. Rusted Barrel	" "	September 87
6. Get the Drift	Magic Island	October 87
7. Exposed Pipe	Kualoa Point	January 88
8. Exposed Roots	" "	" "
9. Uprooted Tree	" "	" "
10. Hawaiian monk seal	Waikiki Aquarium	March 88
11. Green sea turtle	Sea Life Park	" "
12. Storm Drain Pipe	Diamond Head	November 87
13. Dead Duck	Kahana Bay	January 88
*14. Broken Water Main	" "	" "
*15. Discarded Stove	Waianae coast	October 87
*16. Bent Sign	Lanikai	December 87

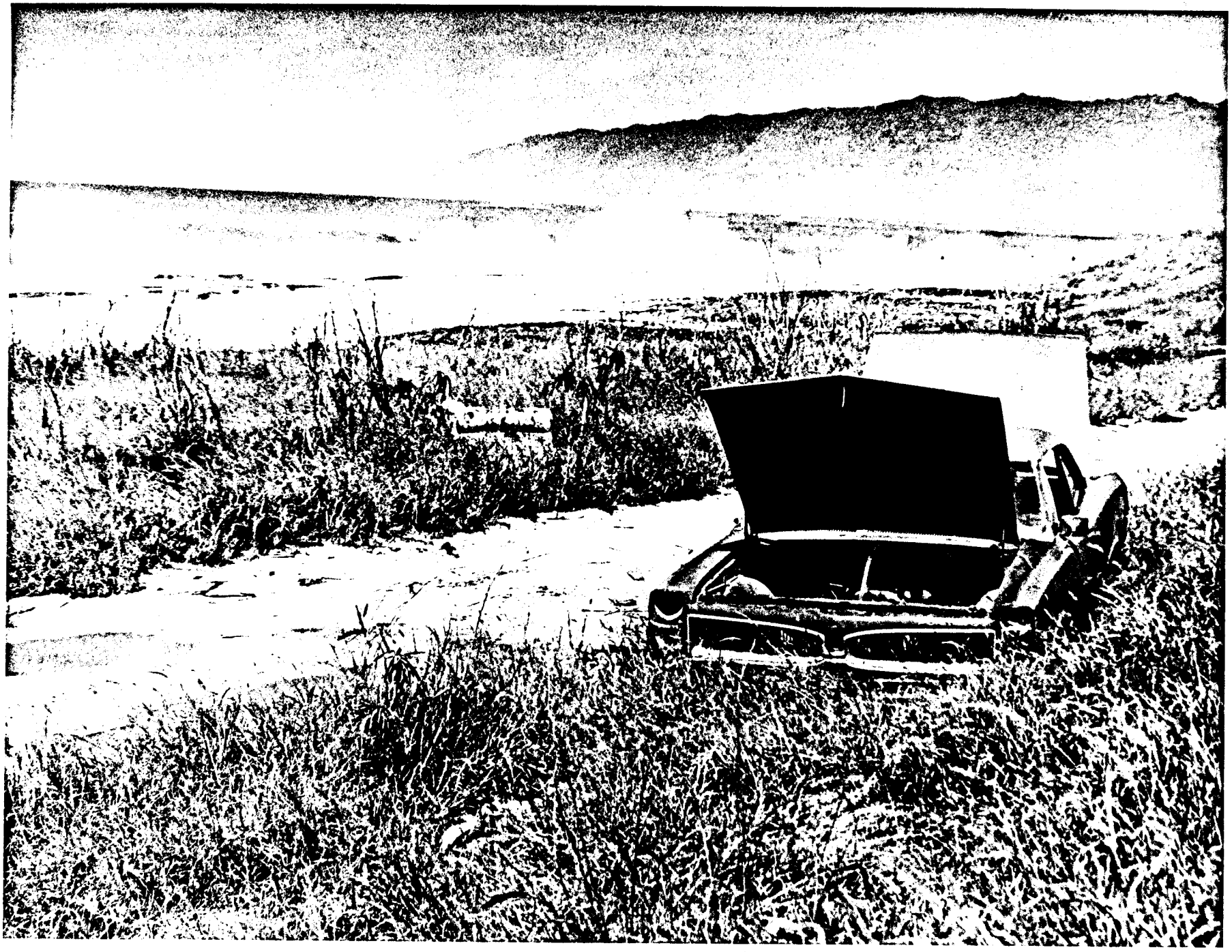
Photographs appear in order they were shown, (as slides) , during Marine Option Program Symposium.
* Photographs not displayed or shown as slides at MOP Symposium.

#1

TRASH, WAIANAE COAST

#2

FOLDING BED, WAIANAE COAST



#3

ABANDONED CAR, WAIANAE COAST

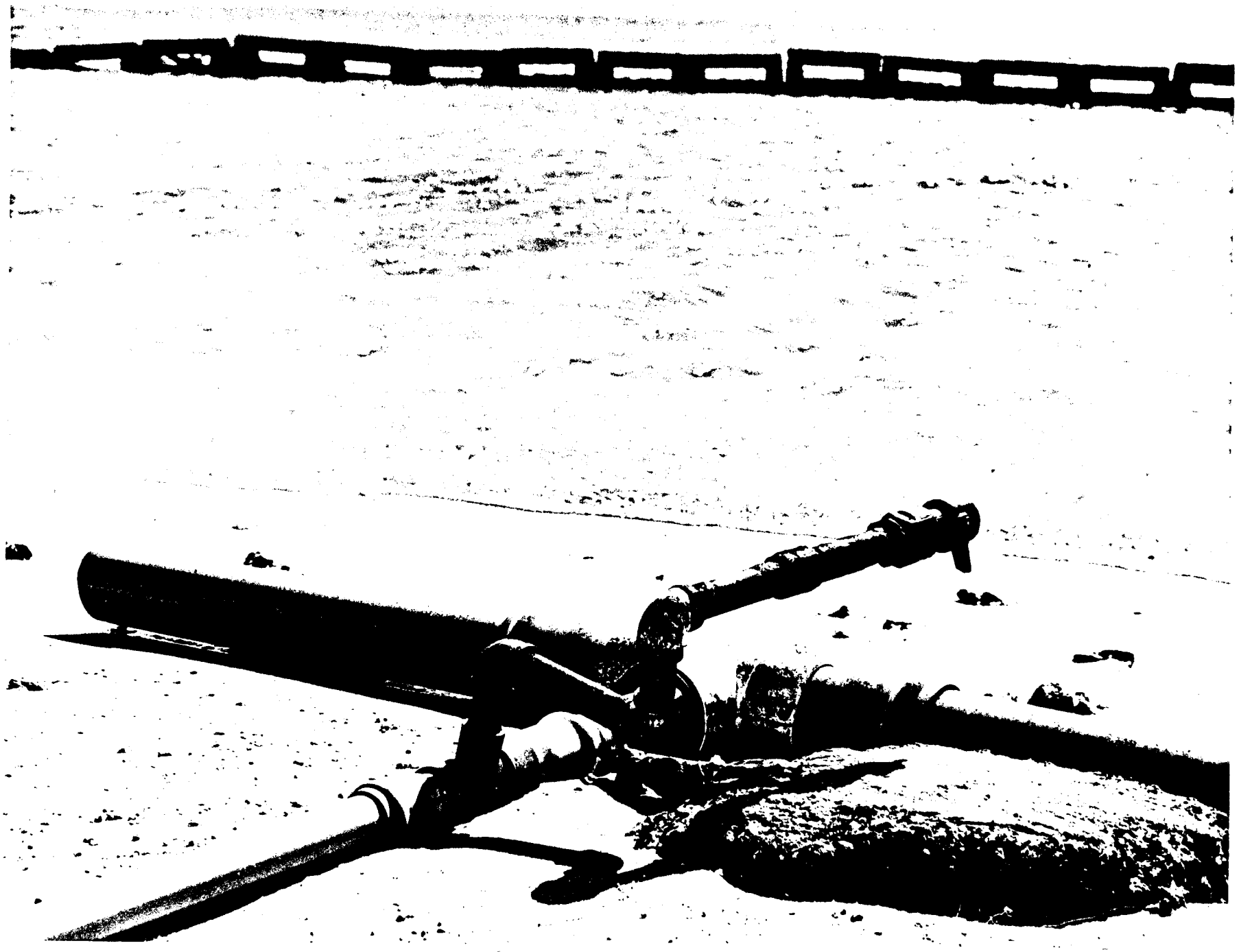
#4 COUCH AND POT, WAIANAE COAST

#5

RUSTED BARREL, WAIANAE COAST

#6

GET THE DRIFT AND BAG IT, MAGIC ISLAND, HONOLULU



#7

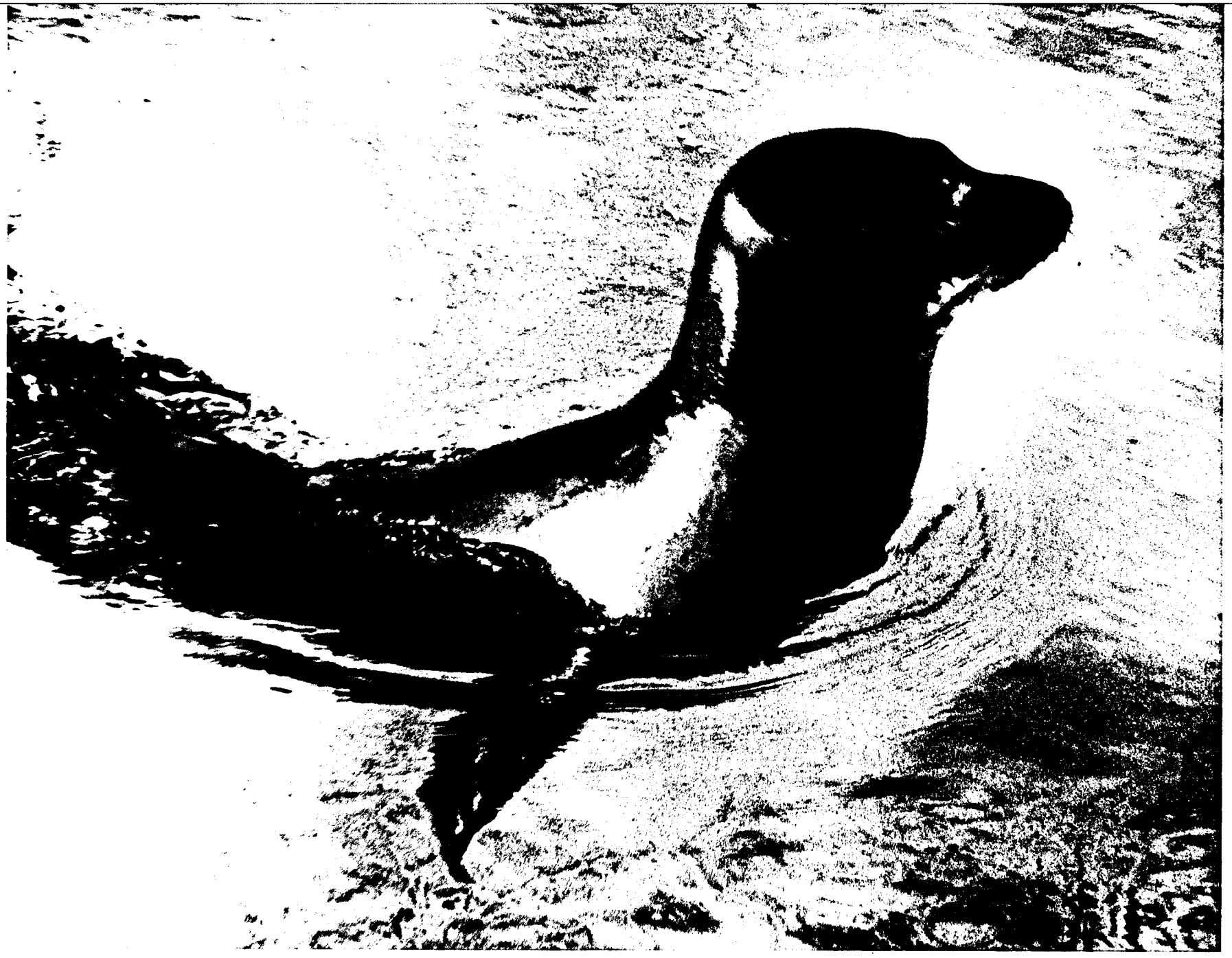
EXPOSED PIPE, KUALOA POINT

#8

EXPOSED ROOTS, KUALOA POINT

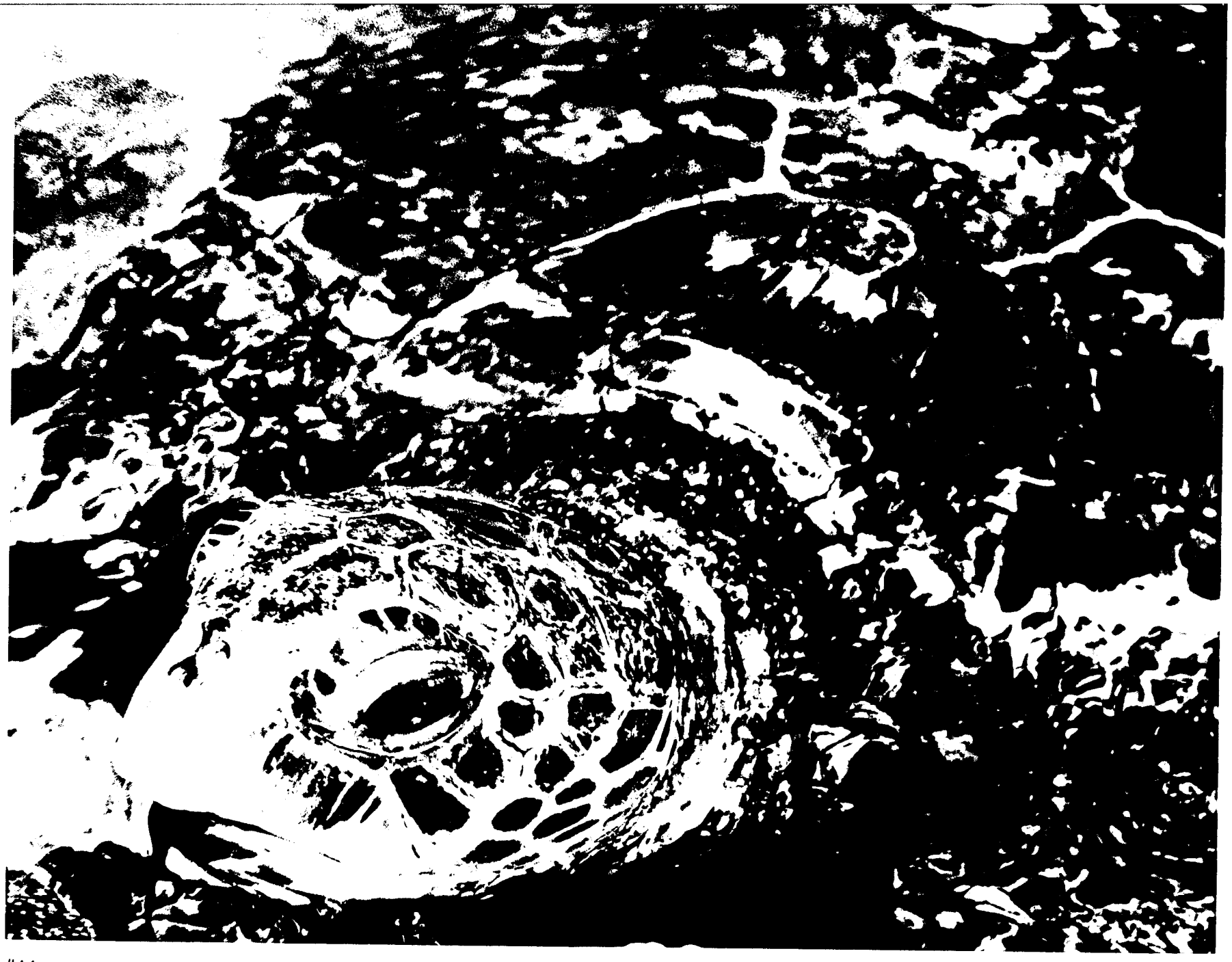
#9

UPROOTED TREE, KUALOA POINT



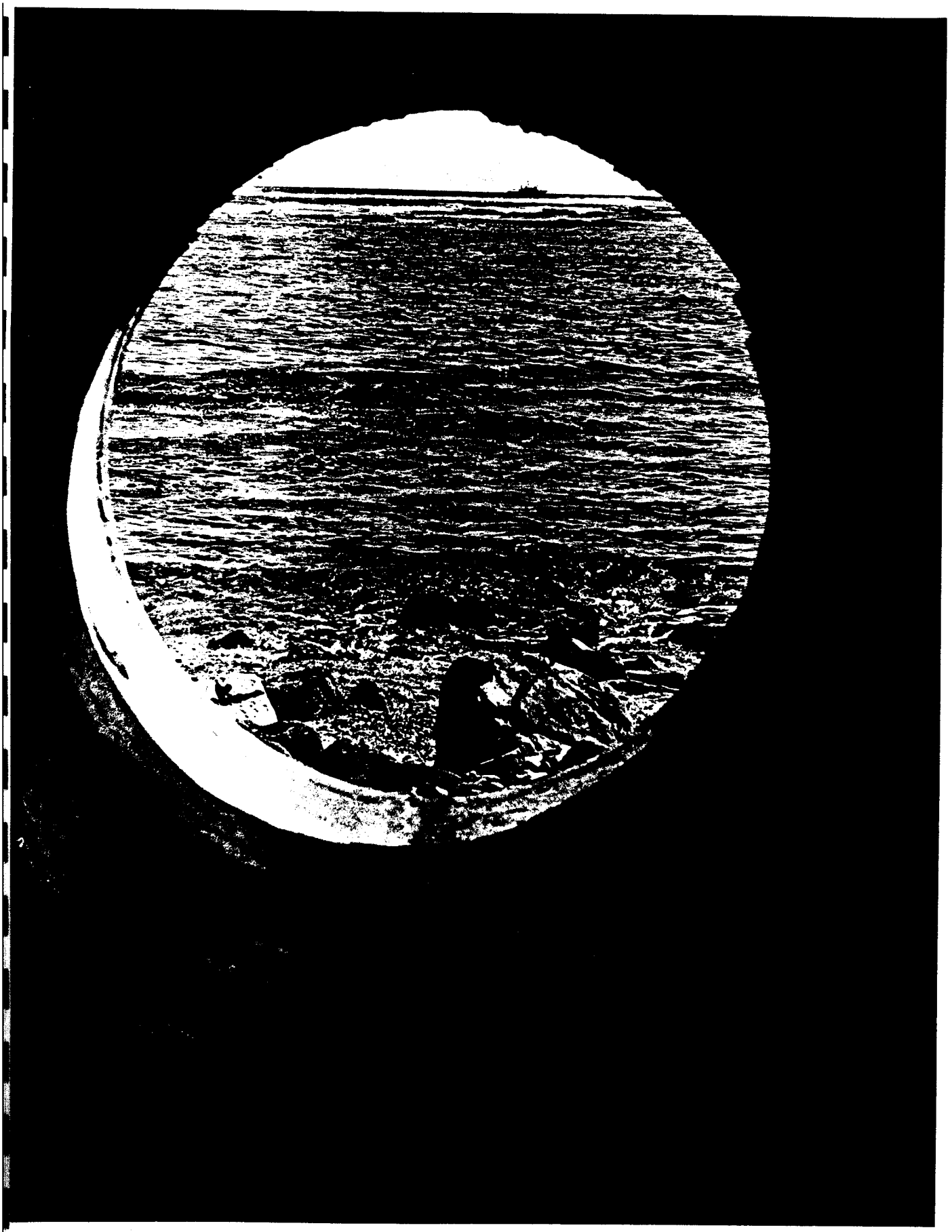
#10

HAWAIIAN MONK SEAL, WAIKIKI AQUARIUM



#11

GREEN SEA TURTLE, SEA LIFE PARK

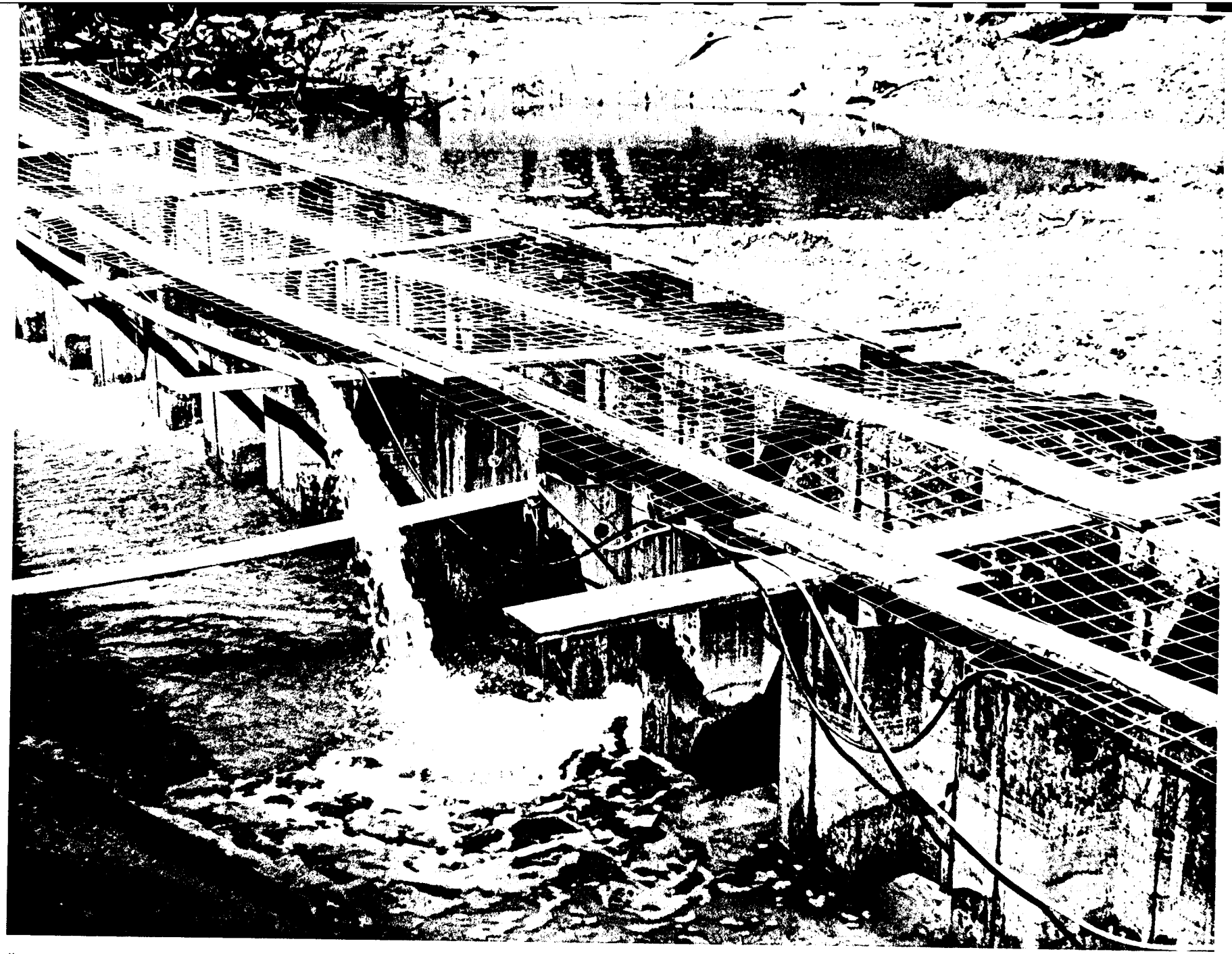


#12

STORM DRAIN PIPE, DIAMOND HEAD

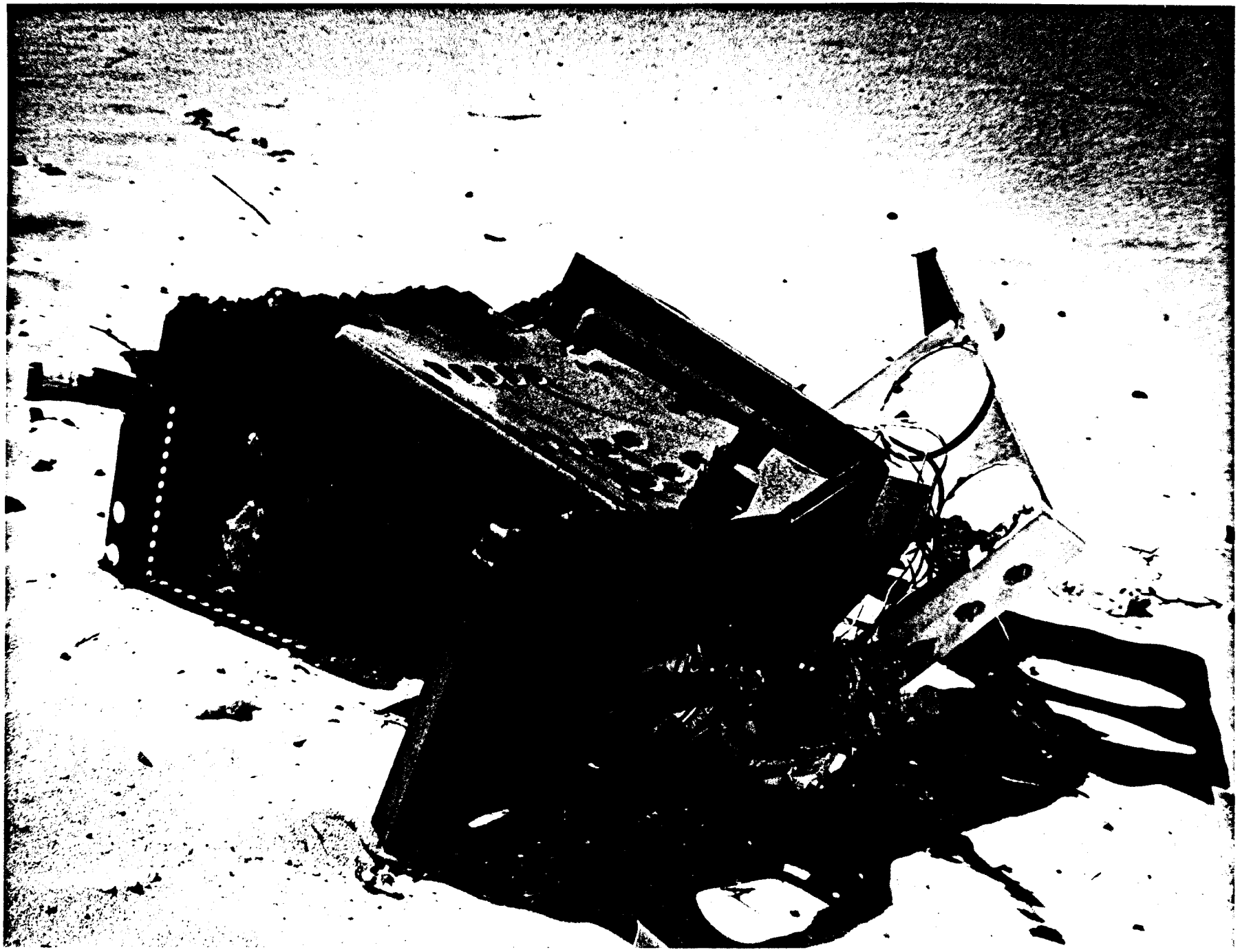
#13

DEAD DUCK, KAHANA BAY



#14

BROKEN WATER MAIN REPAIR, KAHANA BAY



#15

DISGARDED STOVE, WAIANAE COAST

#16

BENT SIGN, LANIKAI

CORAL
REFERENCE

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